

## SHORT COMMUNICATION

### Gregarious behavior of two species of Neotropical harvestmen (Arachnida: Opiliones: Gonyleptidae)

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**Abstract.** We present the first record and description of the gregarious behavior of the Neotropical harvestmen *Serracutisoma proximum* (Mello-Leitão 1922) and *Serracutisoma spelaem* (Mello-Leitão 1933) (Opiliones: Gonyleptidae: Goniosomatinae) (DaSilva & Gnaspini 2010). We followed and described the pattern of these aggregations over a period of 17 months in a cave in southeastern Brazil. Individuals of the two species aggregated with both conspecifics and heterospecifics during the non-reproductive season (i.e., from October to March, the cool and dry season). Aggregations contained up to 81 individuals, usually with a female-biased adult sex ratio. Multispecific aggregations were usually composed mainly of representatives of one of the two species, suggesting that although these species also aggregate with heterospecifics, there is a preference for aggregating with conspecifics. This study provides novel information on the social behavior of harvestmen, specifically regarding the composition of multispecific aggregations.

**Keywords:** Aggregations, Goniosomatinae, *Serracutisoma proximum*, *Serracutisoma spelaem*, social behavior

The habit of aggregating with conspecifics has been observed in several animal taxa. The forces driving this gregariousness in different organisms include defense against predators (Uetz et al. 2002), food acquisition, reproduction, selection of microhabitats, and thermoregulation (Krause & Ruxton 2002). Life in groups might present costs such as higher competition for resources, increased transmission of parasites, and easier detection by predators, but it also offers some exclusive benefits (see review by Krause & Ruxton 2002; Uetz et al. 2002).

Aggregations are common among harvestmen, having been observed in 41 species belonging to 10 families (Machado & Macías-Ordoñez 2007). In contrast to the spherical aggregations of the Old World harvestmen (Holmberg et al. 1984), Neotropical harvestmen aggregations are defined as groups of three or more individuals with bodies 0–5 cm apart from each other and legs overlapping (cf. Machado et al. 2000). Several hypotheses have been proposed to explain how and why harvestmen aggregate, including defense against predators, physiological protection against harsh winter conditions (unlikely to apply for the loose aggregations of Neotropical harvestmen; see Holmberg et al. 1984; Santos 2007), preferential selection of sites with favorable microclimatic conditions, and preferential attachment of individuals (review in Machado & Macías-Ordoñez 2007).

The harvestmen *Serracutisoma spelaem* (Mello-Leitão 1922) and *Serracutisoma proximum* (Mello-Leitão 1933) (Laniatores: Gonyleptidae: Goniosomatinae) (DaSilva & Gnaspini 2010) are found in the Ribeira Valley, an area of Atlantic rain forest in southeastern Brazil. This area's climate is characterized by two distinct seasons: a warm and wet season between November and April, and a cool and dry one between May and October (Chelini et al. 2011). *Serracutisoma spelaem* spends its days resting in caves and its nights foraging in the forest (Santos & Gnaspini 2002; Gnaspini et al. 2003). This species reproduces inside the caves during the warm and wet season (October

to March) (Gnaspini 1995). *Serracutisoma proximum* is usually found on vegetation flanking rivers, and females usually lay their eggs on the abaxial surface of leaves hanging above the river surface (Buzatto et al. 2007; but see Ramires & Giaretta 1994; Gnaspini 1996). We found populations of *S. proximum* and *S. spelaem* cohabiting and composing multispecific aggregations in the Moquem cave (24°18'50.4"S, 48°27'18.8"W, at an elevation of approximately 750 m), situated in the Intervales State Park, southeast São Paulo State, southeastern Brazil. Although *S. proximum* shelters in cave entrances (see Chelini et al. 2011), these two species have seldom been found in the same cave (Gnaspini 1996). This is the first record of multispecific harvestmen aggregations involving Goniosomatinae species. To date, information about the gregarious behavior of Goniosomatinae harvestmen is very scarce, but here we describe the aggregations of these two species.

We followed the aggregations of *S. proximum* and *S. spelaem* of the Moquem cave over the course of 15 field trips regularly distributed between August 2004 and December 2005. During each visit to the cave, we identified all the individuals of *S. spelaem* and/or *S. proximum* that we found as adult males, adult females, or juveniles (immatures of the 4<sup>th</sup> and 5<sup>th</sup> instar, distinguished by their size, color, and number of tarsal articles according to Gnaspini 1995) and recorded the specific composition of all aggregations. We included the individuals described as subadults by Gnaspini et al. (2004) in the "adult" count, since they are now recognized as a smaller morph of adults (e.g., DaSilva & Gnaspini 2010).

Over the course of our 15 field trips, we found a total of 49 aggregations (Fig. 1). The aggregations were markedly more common between May and late October, the period corresponding to the non-reproductive dry and cool season (Gnaspini 1996; Buzatto et al. 2007). However, females and juveniles of *S. spelaem* also formed small aggregations in December, January, and February. Seven aggregations were composed exclusively of *S. proximum*, 28 were composed exclusively of *S. spelaem* and 17 were multispecific aggregations containing *S. spelaem*, *S. proximum* and occasionally *Pronitobates* sp. (Gonyleptidae: Mitobatinae). In 10 out of the 17 multispecific aggregations observed, one of the goniosomatines

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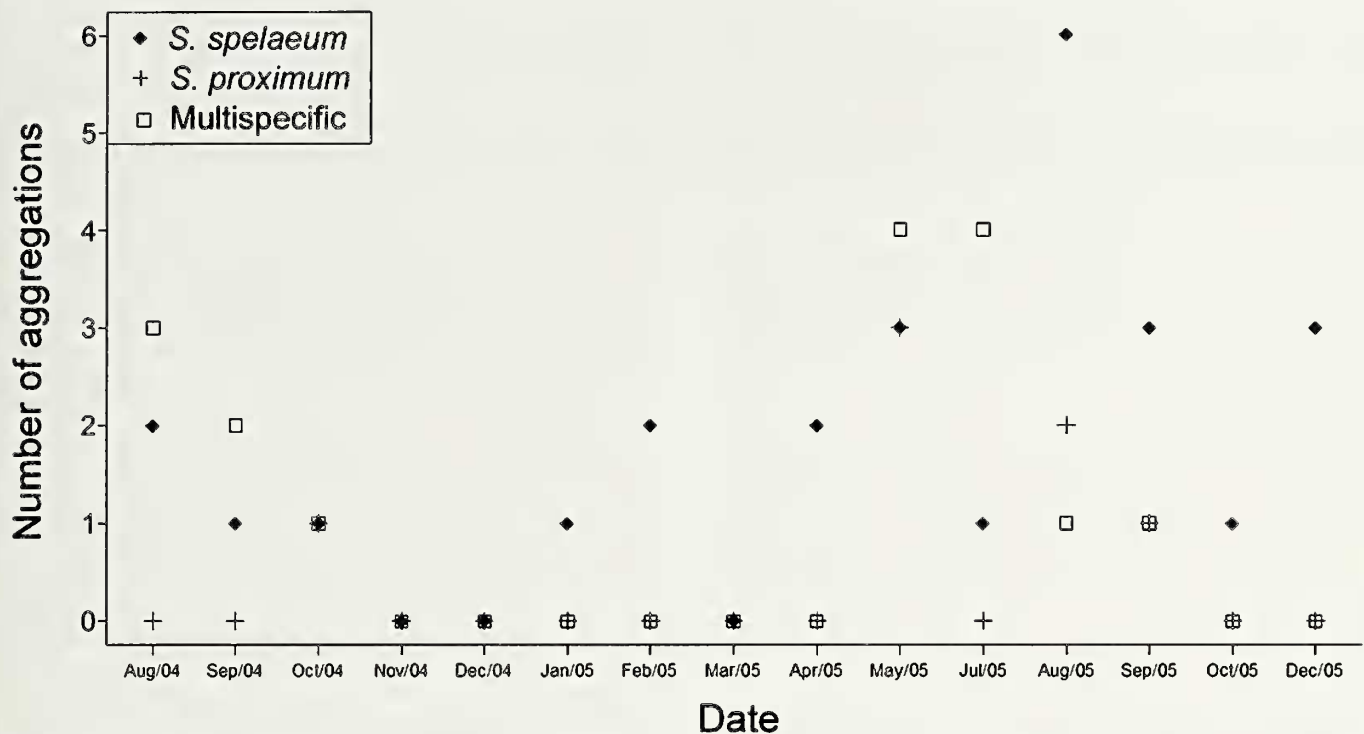


Figure 1.—Number of aggregations composed only of *Serracutisoma proximum*, *Serracutisoma spelaeum* and both species during the study period.

(either *S. proximum* or *S. spelaeum*, and more frequently the former) represented more than 75% of the total number of aggregating individuals. Juveniles of *S. spelaeum* were more common in multispecific aggregations than adults, and adults were found more frequently in conspecific aggregations.

Although the Moquem cave has several ceiling openings, exposed areas (walls directly exposed to sunlight; see Willemart & Gnaspini 2004a) represent only approximately 30% of the cave's total area. *Serracutisoma proximum* seems to aggregate more frequently on these exposed walls of the cave than *S. spelaeum* (71% of their conspecific aggregations are in exposed walls, versus 50% of the *S. spelaeum* conspecific aggregations). Some specific areas of the cave, sometimes with an area no larger than 1 m<sup>2</sup>, seemed to be recurrently used as aggregation sites, while others were never used, suggesting that these species are highly philopatric in relation to their aggregation site (see Gnaspini 1996 and Willemart & Gnaspini 2004b for similar results on another Goniosomatinae species; see also Donaldson & Grether 2007 for an Eupnoi). Regarding the exposure to light of the aggregation sites, *Serracutisoma proximum* may remain close to the epigeal habitat because it is not a typically cavernicolous species (Buzatto et al. 2007), while *S. spelaeum* is an obligatory cavernicolous species whose individuals prefer darker regions of the cave (Gnaspini 1996; Gnaspini et al. 2003). Supporting this hypothesis, an experimental study on the physiological preferences of several Goniosomatinae species pointed out that *S. spelaeum* constantly prefers darker refuges than *S. proximum* (Santos 2003).

The number of multispecific aggregations that we found indicates that aggregating with heterospecifics is not just an occasional occurrence, but rather a frequent behavior exhibited by both the goniosomatines studied here. If harvestmen aggregations have a defensive function against predators, the presence of individuals from a different species could increase its defensive potential. This could be due to different sensory capabilities of a non-conspecific individual, to differences in the chemical properties of its repugnant substance, and/or simply to the increase in the number of individuals able to detect a

predator (see Machado & Vasconcelos 1998). Our data suggest, however, that there is a preference for aggregating with conspecifics, independent of the aggregation placement. Gnaspini (1996) noticed that individuals of *S. spelaeum* followed only a few specific "trails" to leave from and return to the caves they used to shelter during the day. It is possible that individuals recognize conspecific chemical marks more easily, which would lead to a higher probability of finding and aggregating with conspecifics (see Donaldson & Grether 2007; Grether & Donaldson 2007). This hypothesis remains to be tested with an adequate experimental approach.

The conspecific aggregations of both species had strongly female-biased sex ratios. Although this result follows the pattern found in other harvestmen (Machado et al. 2000; Machado & Raimundo 2001; Machado 2002; Willemart & Gnaspini 2004b), it appears that the entire *S. spelaeum* population goes through a change in its sex ratio during the non-reproductive season (see also Gnaspini 1995), and that this population-biased sex ratio is reflected in the aggregations. The median adult sex ratios (male:female) of the conspecific aggregations were 1:1.54 for *S. proximum* (min-max = 5:12–3:1; *n* = 7), and 1:2 for *S. spelaeum* (min-max = 0:5–1:2, *n* = 28). The median adult sex ratio (male:female) of the *S. spelaeum* population (considering both aggregated and isolated individuals) was strongly female biased in the cool and dry months (1:2.76, min-max = 1:1.06–1:7.16), but not in the warm and wet season (1:0.88, min-max = 1:0.21–1:1.64). The median adult sex ratio of the *S. proximum* population (male:female) was 1:1.16 during the cool and dry season. We could not calculate a median population sex ratio for this species during the warm and wet season, since *S. proximum* seldom enters the cave in the reproductive season (Chelini et al. 2011). Since *S. proximum* and *S. spelaeum* only form aggregations during the dry and cool season (Fig. 1), the aggregations' sex ratio cannot be calculated for the warm and wet reproductive season.

We hypothesize that this female-biased sex ratio is related to the agonistic behavior of the males. Male *S. proximum* and *S. spelaeum* are known to fight with other males during the reproductive season (Buzatto et al. 2007; M.-C. Chelini unpublished data). Some males may remain intolerant of the close presence of other males even



during the non-reproductive season. These harvestmen would benefit from the defensive advantages of being aggregated (e.g., dilution effect, confusion effect; Krause & Ruxton 2002; Uetz et al. 2002) during the cold and dry season, but would separate through the reproductive season. The frequently high intraspecific predation of eggs (Buzatto et al. 2007; Willemart et al. 2007; Requena et al. 2009), along with male-male competition, could counterbalance the defensive benefits of being aggregated in the warm and wet months.

With this study, we bring new information to the knowledge of harvestmen social behavior. Although purely descriptive, our data seem to indicate that the selection of aggregation sites by *S. spelaeum* and *S. proximum* is not driven by the search for ideal microclimatic conditions, since we detected both species aggregating in places as different as the entrance of the cave (exposed to the light, subject to higher temperature fluctuation and influence of the external environment) and the aphotic zone of the cave (in complete darkness, with temperature and humidity practically constant throughout the day and throughout the year; Chelini et al. 2011). Our data are thus concordant with Willemart & Gnaspini (2004b), according to whom harvestmen aggregations are a defensive strategy incompatible with reproduction. Experimental studies remain to be designed and executed in order to test the different hypotheses relative to harvestmen's gregarious behavior and, more specifically, the costs and benefits of aggregating with heterospecifics.

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#### LITERATURE CITED

- Buzatto, B.A., G.S. Requena, E.G. Martins & G. Machado. 2007. Effects of maternal care on the lifetime reproductive success of females in a Neotropical harvestman. *Journal of Animal Ecology* 76:937–945.
- Chelini, M.C., R.H. Willemart & P. Gnaspini. 2011. Caves as a winter refuge by a Neotropical harvestman (Arachnida, Opiliones). *Journal of Insect Behavior* 24:393–398.
- DaSilva, M.B. & P. Gnaspini. 2010. A systematic revision of Goniosomatinae (Arachnida: Opiliones: Gonyleptidae), with a cladistic analysis and biogeographical notes. *Invertebrate Systematics* 23:530–624.
- Donaldson, Z.R. & G.F. Grether. 2007. Tradition without social learning: scent-mark-based communal roost formation in a Neotropical harvestman (*Prionostemma* sp.). *Behavioral Ecology and Sociobiology* 61:801–809.
- Gnaspini, P. 1995. Reproduction and postembryonic development of *Goniosoma spelaeum*, a cavernicolous harvestman from southeastern Brazil (Arachnida: Opiliones: Gonyleptidae). *Invertebrate Reproduction and Development* 28:137–151.
- Gnaspini, P. 1996. Population ecology of *Goniosoma spelaeum*, a cavernicolous harvestman from south-eastern Brazil (Arachnida: Opiliones: Gonyleptidae). *Journal of Zoology* 239:417–435.
- Gnaspini, P., M.B. DaSilva & F. Pioker. 2004. The occurrence of two adult instars among Grassatores (Arachnida: Opiliones)—A new type of life-cycle in arachnids. *Invertebrate Reproduction and Development* 45:29–39.
- Gnaspini, P., F. Santos & S. Hoenen. 2003. The occurrence of different phase angles between contrasting seasons in the activity patterns of the cave harvestman *Goniosoma spelaeum* (Arachnida, Opiliones). *Biological Rhythm Research* 34:31–49.
- Grether, G.F. & Z.R. Donaldson. 2007. Communal roost site selection in a Neotropical harvestman: habitat limitation vs. tradition. *Ethology* 113:290–300.
- Holmberg, R.G., N.P. Angerilli & L.J. LaCasse. 1984. Overwintering aggregations of *Leiobmum paessleri* in caves and mines (Arachnida, Opiliones). *Journal of Arachnology* 12:195–204.
- Krause, J. & G.D. Ruxton. 2002. *Living in groups*. Oxford Series in Ecology and Evolution. Oxford University Press, Oxford.
- Machado, G. 2002. Maternal care, defensive behavior, and sociality in Neotropical *Goniosoma* harvestmen (Arachnida, Opiliones). *Insectes Sociaux* 49:388–393.
- Machado, G. & R. Macías-Ordoñez. 2007. Social Behavior. Pp. 400–413. *In* Harvestmen. The biology of Opiliones. (R. Pinto-da-Rocha, G. Machado & G. Giribet, eds.). Harvard University Press, Cambridge, Massachusetts.
- Machado, G. & R.L. Raimundo. 2001. Parental investment and the evolution of subsocial behaviour in harvestmen (Arachnida Opiliones). *Ethology, Ecology and Evolution* 13:133–150.
- Machado, G., R.L. Raimundo & P.S. Oliveira. 2000. Daily activity schedule, gregariousness, and defensive behaviour in the Neotropical harvestman *Goniosoma longipes* (Opiliones: Gonyleptidae). *Journal of Natural History* 34:587–596.
- Machado, G. & C.H. Vasconcelos. 1998. Multispecific aggregations in Neotropical harvestmen (Opiliones, Gonyleptidae). *Journal of Arachnology* 26:389–391.
- Ramires, E.N. & A.A. Giarretta. 1994. Maternal care in a Neotropical harvestman, *Acutisoma proximum* (Opiliones, Gonyleptidae). *Journal of Arachnology* 22:179–180.
- Requena, G.S., B.A. Buzatto, R. Munguia-Steyer & G. Machado. 2009. Efficiency of uniparental male and female care against egg predators in two closely related syntopic harvestmen. *Animal Behaviour* 78:1169–1176.
- Santos, F.H. 2003. Estudo de parâmetros fisiológicos relacionados ao modo de vida cavernícola em Goniosomatinae (Opiliones, Gonyleptidae). PhD dissertation, Instituto de Biociências, Universidade de São Paulo, Brazil.
- Santos, F.H. 2007. Ecophysiology. Pp. 473–488. *In* Harvestmen. The biology of Opiliones (R. Pinto-da-Rocha, G. Machado & G. Giribet, eds.). Harvard University Press, Cambridge, Massachusetts.
- Santos, F.H. & P. Gnaspini. 2002. Notes on the foraging behavior of the Brazilian cave harvestman *Goniosoma spelaeum* (Opiliones, Gonyleptidae). *Journal of Arachnology* 30:177–180.
- Uetz, G.W., J. Boyle, C.S. Hieber & R.S. Wilcox. 2002. Antipredator benefits of group living in colonial web-building spiders: the 'early warning' effect. *Animal Behaviour* 63:445–452.
- Willemart, R.H., M.C. Chelini, R. Andrade & P. Gnaspini. 2007. An ethological approach to a SEM survey on sensory structures and tegumental gland openings of two Neotropical harvestmen (Arachnida, Opiliones, Gonyleptidae). *Italian Journal of Zoology* 74:39–54.
- Willemart, R.H. & P. Gnaspini. 2004a. Breeding biology of the cavernicolous harvestman *Goniosoma albiscryptum* (Arachnida, Opiliones, Laniatores): sites of oviposition, egg batches characteristics and subsocial behaviour. *Invertebrate Reproduction and Development* 45:15–28.
- Willemart, R.H. & P. Gnaspini. 2004b. Spatial distribution, mobility, gregariousness, and defensive behavior in the Brazilian cave harvestman *Goniosoma albiscryptum* (Arachnida, Opiliones, Laniatores). *Animal Biology* 54:221–235.

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